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Changes in weeding practices in the cotton-growing zone of Northern Cameroon

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Abstract

During the rainy season, farmers in the West African cotton belt concentrate their physical and financial efforts on attempting to control weeds. Their priorities at the start of the season are sowing and weeding food crops; the plots intended for cotton are then cleared, generally using animal-drawn ploughs, which often results in only superficial, irregular tillage. The weed clearance provided by tillage is particularly short-lived if the weeds are only partially dug in, and weed problems increase the later the crops are sown. Farmer practices in northern Cameroon for land preparation and weed control have changed substantially as a result of R&D programmes. In 1976, Cameroon was the first French-speaking African country to introduce pre-emergence herbicides on cotton and maize crops, under an intensification drive including tillage with light machinery. Paraquat, which was introduced in 1987 and initially only used in mixtures with pre-emergence herbicides, is now very widely used, and has contributed to the success of direct seeding on a weed mulch. Glyphosate has been used since 1996, following the introduction of diuron and atrazine in 1992, which replaced the binary products distributed previously, hence cutting costs and significantly increasing the areas of cotton and maize treated. These four generic herbicides are now a driving force in changing cropping systems. Within cotton-maize rotations, chemical weeding facilitates integrated control type approaches. However, herbicides can increase weed invasion problems when used as part of an extensification strategy. The organisational conditions that enabled the impressive development of chemical weeding in northern Cameroon included the integration into the cotton commodity channel of training, monitoring, logistics and credit operations.

Introduction

During the rainy season, Sudanian-Sahelian farmers devote most of their time, energy and money to trying to control weeds. On a farm scale, weeds are a major

constraint - and almost certainly the most important in rainy years - that delay implementation of the agricultural calendar and reduce crop yields. Smallholder practices concerning soil preparation, herbicide treatments and in-crop weed control, have changed considerably in recent years in the cotton-growing zone of northern Cameroon. As a result of Research and Development, farmers have reacted to the increasing constraints with which they are faced by determinedly integrating four common herbicides into their production strategies and using them in an increasingly diversified way. Our many start-of-season tours of the herbicide test networks set up by the research sector and the demonstration plots organized by extension, or simply our talks with working farmers provided us with a clear picture of the variability of soil surface condition and weed infestation situations following the change in smallholder practices.

Weed infestation, a recurrent constraint

As in the whole of the Sudanian-Sahelian cotton belt, farmers' first concern at the start of the rainy season is planting food crops, primarily to satisfy household food requirements. In northern Cameroon, for instance, large areas of sorghum are planted as soon as the first useful rains come, by hand, without tillage or herbicides. This first cereal crop is rapidly invaded by weeds, with the weeds emerging and growing at roughly the same time as the sorghum. To ensure good crop establishment, it is important to protect the sorghum seedlings against the strong early competition from weeds for water and mineral supplies, but also for sunlight. In the crop calendar, sorghum crops are weeded directly after planting. This takes quite a long time, as it is done very carefully with a hoe, so as to prevent the weeds from growing again after subsequent rain and to destroy as many seedlings as possible, hence ensuring long-lasting weed control. Groundnut is often planted after sorghum as a mixed food and cash crop, and benefits from the same attention in order to ensure effective establishment.

Cotton is not planted until after the priority food crops; the same goes for maize, which comes either side of cotton in crop calendars (Dugué and Dounias, 1995). Plots that already contain weeds are cleaned, generally by ploughing, as hand-hoeing takes too long. With animal drawn implements, plough size and characteristics obviously affect their working depth and ability to bury weeds. The problems with burying weeds depend on the extent of weed cover at the time of tillage, and increase geographically from north to south with rainfall and over time as the rainy season progresses. The problems are exacerbated by the often insufficient training and pulling power of the animals used and the fact that wearing parts are often replaced too late. Moreover, there is still a shortage of draught animals and ploughs in northern Cameroon, and many farmers have to use contractors for tillage. With the area planted with cotton expanding rapidly as in recent years, demand becomes very strong and tillage, paid on an area basis, is increasingly done hastily, to the detriment of quality. Ploughs are used like half-ridger bodies, the rows are as wide apart as possible, and the strip of soil displaced by the ploughshare is spread by the mould board over unploughed land. Weeds are more or less cleared from the whole area, but the topsoil is only broken up over half the area. The weeding effect achieved is all the more short-lived if the weeds are only partly buried and the clumps of weeds are vigorous. The weeds are often

transplanted in regular rows. After tillage (or hoe-weeding), there are two modes of plot invasion by weeds: seedlings and regrowth after tillage (or weeding). Germination and regrowth are more rapid and intense if the tillage has been poor. However, it is often regrowth that determines the speed of reinfestation, and thus the characteristics of the first weeding round: time, duration and difficulty. In turn, the efficacy of the first weeding round depends on the extent of plant growth and the care taken with the operation. Weed growth is thus increasingly problematic the later the crops are planted, and it is far from uncommon, particularly in rainy years, for farmers to be completely overwhelmed by the rate of weed development.

In cotton crops, weeds reduce the efficacy of mineral fertilizers, which would explain why farmers tend to prefer low fertilizer rates: around half those initially recommended by researchers and developers (Guyotte, Martin and Ekorong, 1997). In effect, thinning and the first fertilizer application depend on the timing of the first weeding round, as they are done at the same time or just afterwards. A difficult, long first weeding round delays thinning and fertilizer applications in all or part of the plot. Early competition slows plant growth, increases the incidence of certain diseases such as bacterial blight or *Alternaria* and reduces crop production potential. This logically pushes growers to limit fertilizer applications, particularly in the case of late planting and/or weeding.

Herbicides in northern Cameroon, a quarter of a century of history

In 1976, Cameroon was the first French-speaking African cotton-growing country to use herbicides, on cotton and food crops. SODECOTON introduced pre-emergence herbicides in the wake of crop intensification (fertilizers) and light mechanization (Bouyer tractors) in southern Garoua. Production potentials in the area are high, but the shortage of manpower and draught animals and the early, abundant rainfall (> 1 000 mm in six months) mean that weeds are a major problem. Mechanizing soil preparation and earthing up has reduced the problem of establishment and the last weeding round, but there are still problems with burying weeds and weeding, as the areas per worker and per tractor are relatively large.

Harrows were introduced to improve the efficacy of pre-emergence herbicides. In the absence of mechanical seeders, the crops can be sown by hand after rough preparation (a single ploughing round without harrowing), but fine soils were seen as a prerequisite for effective herbicide treatments. Experience has shown that harrows were used like rakes to remove the weeds not buried by ploughing. Thorough weed extraction calls for crossed harrowing passes, which completely destroy the rough surface obtained after ploughing, increasing runoff and sheet erosion. In these undulating landscapes with very severe erosion, repeating such practices speeds up the soil degradation process.

In 1987, paraquat, a total contact herbicide, was introduced in the hope of solving the problem of regrowth after tillage. Land tilled by animal draught or even by motorized equipment can be recolonized by weeds due to those that are not sufficiently buried (regrowth) or to new growth as a result of a long time lapse between tillage and planting (often due to showers of rain that are not sufficient for good crop emergence),

or to a combination of the two. With the advent of paraquat, harrowing was rapidly abandoned. Pre-emergence treatments were no less effective, as their efficacy apparently depends more on soil moisture contents at the time of application than on the care taken with soil preparation. Moreover, provided regrowth has been controlled, stopping harrowing seems to reduce weed pressure, since seeds sprout less easily and more slowly on areas simply ploughed. As regards erosion, ploughing land without harrowing leaves clods of earth held together or protected by more or less buried clumps of weeds, which provides a surface open to infiltration and less unstable than following tilling and then harrowing.

Paraquat was initially introduced in a tank mixture with pre-emergence herbicides. As the immediate effects of paraquat were clear to see, other more diversified uses were then suggested. Farmers rapidly grew to appreciate the possibilities, and within a few years, the product had been adopted and used in a wide variety of ways, sometimes following farmer experimentation and passed on from person to person. In addition to its main use, paraquat is used alone, post-planting on non-harrowed land, or before tillage to ensure more effective seedbed preparation and a more persistent weed control. The range of doses is also wide: single or double, if not triple doses, often staggered by splitting treatments, which increases efficacy and/or reduces the overall dose (Martin and Gaudard, 1996).

Developments since 1992

Lastly and above all, paraquat, used alone or mixed with pre-emergence herbicides, has enabled the development of direct seeding on a weed mulch without tillage. This planting technique has really taken off in recent years, against a favourable backdrop: the decline of mechanization and problems with trypanosomiasis and with keeping draught animals, and the increase in the areas planted with cotton following the devaluation of the CFA franc in 1994. This preparation technique is also faster than tillage and enables earlier planting, which is a major factor in the productivity and profitability of cotton plantings (Dugué and Guyotte, 1996). Even if subsequent weeding is done traditionally, ie using draught animals or by hand, direct seeding on a weed mulch has the advantage of reducing direct soil exposure to the rain and thus reduces erosion during the critical period until the crop is fully established.

Since 1992, the pre-emergence herbicides distributed have been generics : diuron for cotton and atrazine for maize. At low doses, in finely sprayed, wettable powder form or now for the 2000-2001 season in soluble granule form, packed locally in individual sachets to treat a quarter of a hectare, these products have enabled a drastic reduction in costs compared to the binary products in concentrated suspension form used previously. This has made pre-emergence herbicides economically competitive again (Martin and Gaudard, 1996), as shown by the spectacular increase in the areas of cotton and maize treated since 1992, all methods combined (figs. 1 and 2)(Abaïcho and Gaudard, 1999). In 1999, over half the areas planted with cotton were treated with herbicides in one way or another. Herbicide use, which is widespread in the southern part of the cotton-growing zone, is expanding significantly in the centre and even in the north of the zone.

Figure1. Evolution of cotton planted areas treated with herbicides.
(Source : Sodecoton)

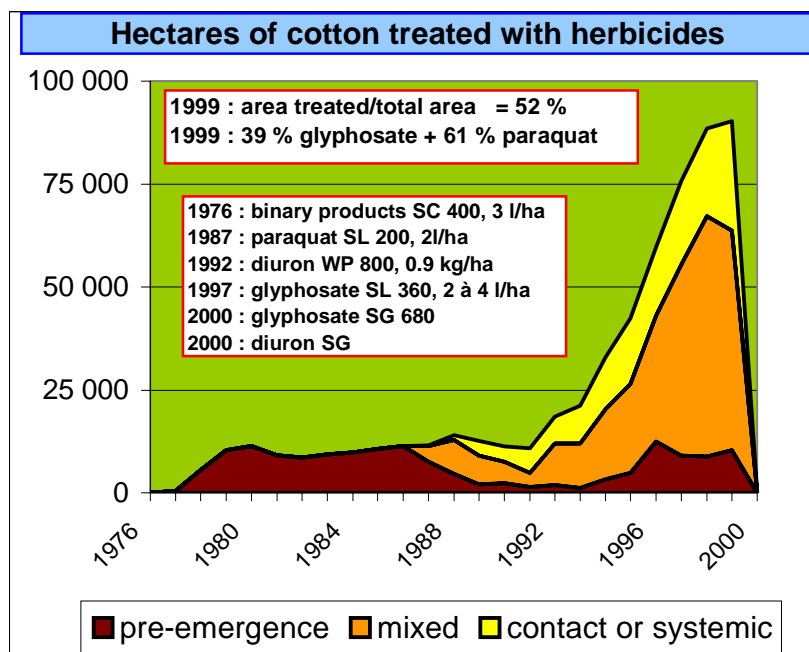
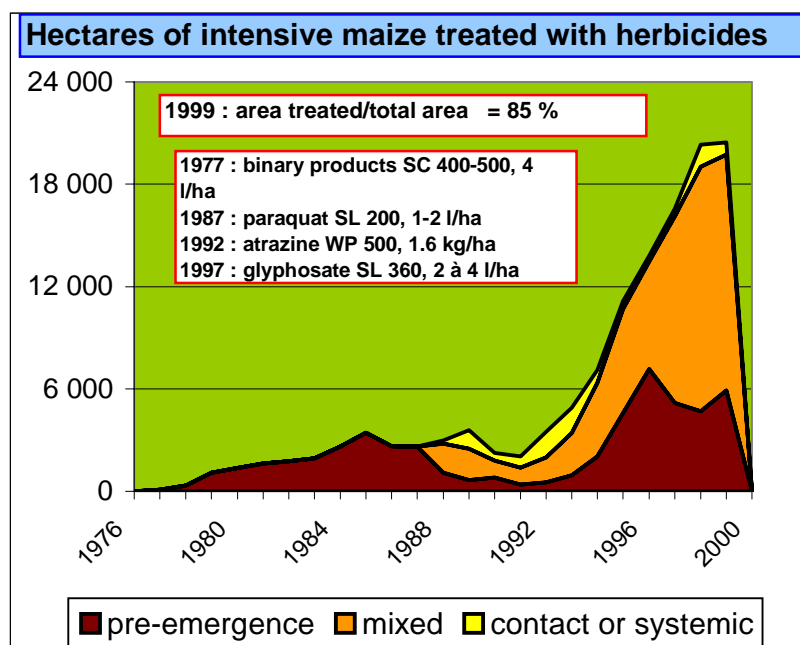


Figure 2. Evolution of intensive maize planted areas treated with herbicides (Source : Sodecoton)



Growers rapidly learnt the differences and complementarities between the three types of herbicide (paraquat, diuron and atrazine), used alone or in tank mixtures, with very precise observations as to their effects. Pre-emergence herbicides kill seedlings as they sprout, but also strengthen the effect of paraquat on the weeds already present at the time of treatment. The shock effect of paraquat is followed by the more persistent effect of pre-emergence herbicides, which are taken up by the roots and inhibit photosynthesis; this slows and inhibits the resumption of growth of the weeds affected but not killed by paraquat. Growers are very aware of this effect, which helps to explain the increase in mixed treatments on cotton, whether in conventional systems including tillage or in systems using direct seeding.

Since prices have fallen due to competition, glyphosate has become the fourth pillar of chemical weed control in northern Cameroon. It is primarily used to prepare for direct seeding, as although it acts much more slowly than paraquat, its effect is more complete and homogeneous. It is undeniably of value in controlling certain perennials such as *Cyperus rotundus* and *Imperata cylindrica* in cotton rotations, but also *Oryza longistaminata* on vertisols used for off-season transplanted sorghum. The other advantages of glyphosate over paraquat include its non-toxicity to users. The new high-concentration soluble granule formulations are ideal for the situation in the area as they make for reduced transport costs and storage problems and are repacked in individual doses.

Herbicides and integrated control

Pre-emergence treatments are particularly appropriate in the case of soil preparation techniques for sowing that encourage rapid, dense weed infestation of the crop. For instance, treatment is of less use after deep, regular ploughing (which is rare) on an area previously kept clear than after rapid, i.e. superficial and irregular, tillage on an area previously heavily infested by weeds.

Through its diversification, chemical weed control facilitates integrated type control strategies. *Commelina benghalensis*, a weed of major economic importance in northern Cameroon and elsewhere in West Africa, is a good example of this.

Germination of this weed is triggered by soil tillage: superficial tillage or hoe-weeding. This nitrophilous plant produces a multitude of aerial and underground seeds, and has a remarkable aptitude for vegetative propagation: it grows after weeding from the stems left on the ground, which put out cauline roots. Its growth is favoured by regular, abundant rainfall, and it has become a real menace for growers in the southern half of Cameroon's cotton-growing zone (Le Bourgeois, 1993).

Simultaneous emergence of *Commelina benghalensis* and the crop often results in very strong competition for water, minerals and above all sunlight. There are several possible solutions to this:

- the stale seedbed technique: early soil tillage triggers early emergence of the weed, which is killed by a contact herbicide at the time of sowing; in practice, this solution is not applied as the growers do not have enough draught animals and

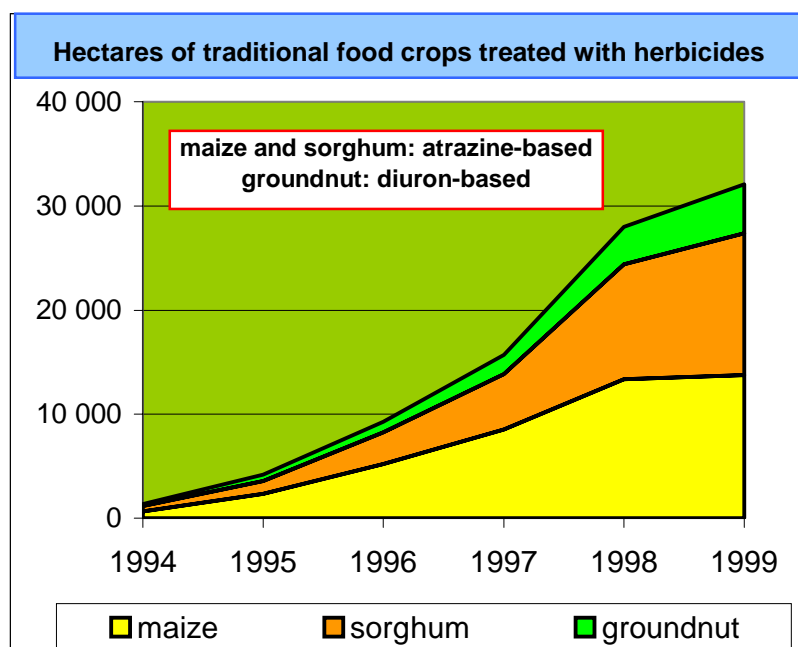
ploughs. Also draught power requirements are higher early in the season as the soil is less damp.

- direct seeding without tillage: large-scale *Commelina benghalensis* emergence is postponed and the more balanced, less aggressive flora is controlled for a few weeks by a mixed contact - pre-emergence herbicide treatment; this technique is increasingly common, as it compensates for the growers' lack of equipment.
- using a pre-emergence herbicide postpones *Commelina benghalensis* germination in the very common case of sowing after superficial tillage; on maize, the effect is highly persistent, but on cotton, it generally lasts just two to three weeks. This gives the cotton plants a decisive but not definitive advantage, as the density and speed of *Commelina benghalensis* growth are higher than those of cotton plants. Weeding when the weed has three to four leaves is thus essential to reduce its remarkable ability to grow by putting out cauline roots.

In any event, the next weeding round in turn triggers a wave of *Commelina benghalensis* emergence, the second for a stale seedbed and the first for direct seeding. The wave is more or less significant depending on the extent of the previous ones, but is still likely to result in quite strong competition for water and minerals, particularly nitrogen, at a time when crop requirements are higher. The potential for infestation from one year to the next stems from the seeds formed by the plants that survive weeding and earthing up.

Most maize crops are sown on tilled land and are thus followed by mass *Commelina benghalensis* emergence, against which atrazine provides early, long-lasting protection provided the crop is earthed up. For the same cost, diuron provides cotton with two to three times less effective protection than atrazine on maize (Martin and Gérardaux, 1994). Choosing to treat maize rather than cotton optimizes the allocation of production resources in terms of the cropping plan, but also reduces *Commelina benghalensis* pressure on the subsequent cotton crop. In effect, according to those who have tried it, maize treated with atrazine helps to protect the following crop. These factors explain growers' enthusiasm for pre-emergence or mixed (paraquat - pre-emergence) treatments, not only on intensive maize (treated seeds and mineral fertilizers), but also on so-called traditional maize (no inputs other than herbicides) and other traditional crops (sorghum and groundnut) used in cotton rotations (fig. 3) (Abaïcho and Gaudard, 1999). Moreover, the area in which herbicides are used, which was initially restricted to the south of the cotton-growing zone, has quickly spread northwards, despite the lower rainfall.

Figure 3. Evolution of traditional food crops planted areas treated with herbicides (source : Sodecoton).



Given growers' limited financial resources, they rationalize input allocation to the different crops and plots in the rotation, so as to draw maximum benefit at the least possible risk. Chemical weeding of sorghum (using atrazine, with or without a total herbicide), and groundnut (using diuron, with or without a total herbicide), which was reinitiated in 1994, is spreading quickly. This expansion should continue in the coming years, as on these early-sown crops, the time saved on weeding by using chemicals has a cascading effect on the whole of the farm's operating calendar and on crop yields. When applied to an increased proportion of the food crop there can be a substantial regional impact. Using herbicides on sorghum should favour intensification and reduce weed infestation, provided it is not combined with an increase in the area planted.

Herbicides, extensification and weed invasion

In African cotton-growing countries, chemical weeding is generally an auxiliary technique to soil preparation and mechanical, manual or animal-drawn in-crop weed control. If it is economically affordable, as is now the case in Cameroon with relatively cheap, appropriate active ingredients, formulas and doses, it is widely accepted, as by lightening growers' workloads and reducing weed problems, it significantly increases profitability per man-day. However, between 1994 and 1998, with the devaluation of the CFA franc and a good cotton price, it became clear that the prime conditions for crop establishment and upkeep stemming from herbicide use were also exploited to increase the areas planted, provided land was available. This was particularly true where new land was cleared in immigration areas, a situation in which direct seeding on a weed

mulch is highly effective as a land appropriation tool. Like animal draught, herbicide use is fuelled by strong demand from users, as it enables them to extend the areas planted (Dugué and Dounias, 1995).

When herbicides are used as part of a deliberate extensification strategy, they can prove to increase weed invasion, despite their clear but short-lived clearance effect. If the weeding round scheduled in addition to a diuron treatment is done too late, cotton fields are rapidly invaded by *Commelina benghalensis*, and to an inexperienced observer, it looks as if the herbicide treatment has been ineffective. Thus herbicide treatments that have a cleaning effect at a given time in a given plot can indirectly increase weed invasion later. This is either because the plot is part of a larger farm in which it is not necessarily a priority in terms of the allocation of manpower, or because the tolerated levels of competition are high, since manpower availability is low in relation to the extent of planted areas. When attributing the spread of *Commelina benghalensis* to herbicide use on cotton and to intensification, the appropriate term should be "extensive intensification": intensification because of the mobilization of capital for tillage and/or herbicides and fertilizers, but extensive because the tillage and herbicides serve to increase the areas planted. The farm workforce, which is limited, is thus spread over an increased area, which necessarily results in later and/or less thorough upkeep in all or part of the farm. Conversely, intensification in terms of both capital and labour would act to clear weeds.

Use of plant cover and sustainability

The weed clearance (reduced weed pressure in a given plot) or weed invasion (increase in weed pressure) effects of different cropping systems have generally yet to be determined and modelled. In effect, the different types of soil tillage, herbicide treatments (selection of species), and fertilizers (particularly manure) can have varying, if not contrary, qualitative and quantitative effects depending on how they are used and how they are combined over successive crop rotations. The length of natural fallow periods and the intensity of their exploitation by grazing also have a significant effect on the weed species found in subsequent crops.

The decision to put land into fallow often stems from excessive weed invasion caused by invasive species, particularly in extensive cropping systems when land is easily available. The increase in weed pressure corresponds to a reduction in the range of species in favour of the most competitive ones. The high plant biomass production would seem to suggest that the assumed fatigue of the soil at that stage in fact primarily corresponds to fatigue on the part of the grower, ie his inability to control weed invasion by intensifying in terms of capital and/or manpower. However, at a later stage, the change to fewer and less vigorous species, leading to increasingly poor cover and biomass despite high population densities, is proof of advanced deterioration in soil fertility.

With conventional systems, growing row crops exposes the soil surface to aggressive climatic effects for relatively long periods. This leads to compaction, runoff and erosion on the one hand, and poor rooting and crop growth on the other, with recurrent degrading effects. To remedy this downward spiral, researchers are working

to adapt zero-tillage cropping to the conditions in northern Cameroon. The mulches used comprise crop residues left on the soil and cover crops, but species seen as weeds can also be put to good use. The plant cover plays several roles: it protects against erosion and high temperatures, its biomass is recycled in the soil organo-mineral complex, and a cultural profile favouring plant production is maintained. Herbicides are thus needed when the grower switches from the cover crop back to a row crop, both when planting using total herbicides and in upkeep operations using different types of selective treatments. The changes in the type of weed invasion in such cropping systems have not yet been clearly identified, but it is likely that weed pressure decreases under certain conditions, with biology gradually taking over from chemistry in helping growers to control weeds. With the help of their experience of the common herbicide quartet (paraquat, glyphosate, diuron and atrazine) and of setting up crops on weed mulches, growers in northern Cameroon are apparently well prepared to test cropping systems including a plant cover, provided the random grazing problem is solved.

To conclude, an important reminder

It is important to remember that the impressive increase in chemical weed control on cotton and food crops in northern Cameroon was based not only on research (ICRAD, Institut Camerounais de la Recherche pour le Développement, in conjunction with CIRAD) and development work (Sodecoton, Société de Développement and de commercialisation du Coton, Cameroon) in terms of integrated management of weeds, but also and above all on efficiently organized support of agricultural production as an integral part of the cotton commodity channel, in this case via Sodecoton. This support includes training and monitoring operations, logistics (including product quality control) and credit (small mutual surety groups). This framework is particularly important in promoting good practice and preventing inappropriate usage that may be dangerous for the environment and for users. This technological boom is proof of smallholders' considerable ability to adapt, evolve and rapidly adopt relatively technically complex innovations, provided they are economically affordable and clearly satisfy their requirements: in under ten years, several new techniques have become commonplace whilst modifying, transforming or even completely overturning cropping and production systems.

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